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ROADSIDE HAZARD REDUCTION WITH FIRE RETARDANT CHEMICALS

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ABSTRACT: The use of fire retardant chemicals for season-long fireproofing of roadside vegetation is promising, but solubility of the retardant residue is a problem. Concentration and application techniques also need further study.

In 1962 field experiments were conducted at two locations in California to determine the feasibility of using chemical firebreaks to solve an increasingly important problem--roadside fires. Although the Forest Service, in cooperation with the Army Air Corps, tested retardants on grass some 20 years ago,[1] little has been done since with studies of season-long fireproofing. Only recently have the retardants been developed which might make such a goal possible.

Roadside fires are a major source of damage in California. A recent study on the San Bernardino National Forest indicated that 52 percent of all man-caused fires (except those from railroads) on the Forest occurred within 33 feet of the outer edge of a road.[2] Figures from fire reports (929 forms) computed by the Experiment Station show that on the four southern California National Forests (San Bernardino, Angeles, Cleveland, and Los Padres), 70 to 75 percent of all roadside fires begin within 10 feet of the outer road edge. The California Division of Forestry states

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1/ Alexander, L. T., and Miles, E. F. Fire retardants for use on grass at airports and other military establishments. Part II, Field trials and demonstrations. U.S. Dept. Agr., Bur. Plant Indus. Soils & Agr. Engin. Res. Report No. 2, 9 pp. 1943.

2/ Johnson, R. F. The roadside fire problem. Fire Control Notes. Vol. 24, No. 1, pp. 5-7. 1963.

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that roadside fires average 30 percent of their annual total. Thus, by fireproofing a relatively small area with a small amount of chemicals, we might save many acres of vegetation.

Although several other methods have been used to reduce roadside fire hazard, each has its disadvantages. The mechanical removal of vegetation is expensive, and some areas are too steep or rocky for this method. Roadside burning is often a hazard in itself and can damage planted shrubbery. Cutting by hand is slow, and its cost is usually prohibitive unless free labor is available. Herbicides and sterilants have been used to good advantage, but they may preclude future landscaping.

A new method is needed; one that will last throughout the fire season, be reasonably economical to use, and will not harm the soil or desired vegetation. This paper describes two tests in which we examined four chemical fire retardants to see if any of them might answer this need.

Fire Retardant Chemicals

The four retardants tested were water solutions of: (a) diammonium phosphate, (b) algin—diammonium phosphate, (c) sodium silicate—diammonium phosphate, (d) a combination of algin and sodium silicate—diammonium phosphate.

Diammonium phosphate (DAP) has been recognized for many years as an effective fire retardant. Recently it has been used with success from air tankers on a wide variety of forest fuels. Diammonium phosphate solutions retard fire through chemical action rather than through cooling with water, thus their effectiveness depends primarily upon the amount of dry DAP coating the fuel rather than the water-holding capacity of the solution.3/ Presumably, this coating should remain effective during the dry summer months in California until it is washed off by winter rains. DAP is non-toxic to plants and animals and is readily available as an agricultural fertilizer. Although corrosive to some metals, it has not been a serious problem when used in roadside spray equipment.

Diammonium phosphate solutions.--Plain water solutions of diammonium phosphate were tested in 15, 20, and 28 percent concentrations. DAP is readily soluble and no difficulty was experienced in mixing the various concentrations in an agitating type mixer. However, because of its solubility, there was concern that even light rain would wash it off the vegetation.

3/ Davis, James B., Phillips, Clinton B., Dibble, Dean L., and Steck, Leo V. Operational tests of two viscous-DAP fire retardants. U.S. Forest Serv. Res. Note PSW-N14. 11 pp., illus. 1963.

Algin-diammonium phosphate.--DAP solutions thickened with sodium alginate adhere in thick layers to foliage and stems of vegetation.[4/] The thickened solution not only results in more retardant sticking to the vegetation, but also dries to a somewhat water-resistant film. The algin —a buff colored powder— can be mixed in the same equipment used for mixing diammonium phosphate.

Sodium silicate—diammonium phosphate.--Sodium silicate (water glass) is a syrupy liquid that dries to a water-repellent glaze. The material can be blended with plain water to which the DAP is added.

Sodium silicate—algin—diammonium phosphate combination.--Both algin and silicate were added to DAP in an effort to develop a viscous DAP solution that would form a thick coating on vegetation and eventually dry to a water-repellent glaze.

Test Locations

The tests took place at locations representing typical grass and brush fuels. The first series of tests was conducted near Pleasant Hill in Contra Costa County about 18 miles east of Berkeley. The test site was the bank of a shallow drainage ditch and the adjacent shoulder of State Highway 24 lying about 55 feet above sea level. Rainfall averages 20.51 inches annually. Generally, June to September is a dry period.

The fuel consisted of mixed annual grasses 12 inches to 24 inches high, vegetation common to the valleys and foothills of central California. The most frequently occurring species were soft chess (Bromus mollis), ripgut grass (Bromus rigidus), wild oat (Avena fatua), and Italian ryegrass (Lolium multiflorum).

The second test site was on the Saugus District of the Angeles National Forest, 30 miles northwest of Los Angeles. The site is situated at an elevation of 2,400 feet. Rainfall, most of which occurs during the winter, averages 15.02 inches per year. The vegetation, typical of light to medium stands of southern California chaparral, consisted of annual grass, 4 to 8 inches high, chamise (Adenostoma fasciculatum), 12 to 16 inches high, and buckwheat (Eriogonum sp.).

Test Procedure

Pleasant Hill Tests.--Thirty-six 5- by 20-foot plots were established at the Pleasant Hill site. Three different concentrations of DAP were applied by hand in both thickened (algin-DAP) and unthickened states (table 1). The application rate in each case was 2.0 gallons of retardant

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4/ Langguth, R. P., and Young, H. L. Carboxymethylcellulose as a thickening agent for diammonium phosphate solutions used for firefighting. Monsanto Chemical Co. Special Report 5369. 12 pp. 1962.

solution per 100 square feet (872 gallons per acre). The chemicals were mixed and pumped from a Myers "Right of Way Sprayer" mounted on a truck (fig. 1).

Table 1.--Effects of retardants with various concentrations and drying times, Pleasant Hill site

Retardant & concentration	Time and date of burn	Drying time (days)	Burning intensity	Effects of retardant
DAP (15%)				
First burn	1130 Aug. 14	35	High	Did not stop fire
Duplication	1450 Aug. 14	35	Medium	Did not stop fire
DAP (20%)				
First burn	1150 Aug. 14	35	High	Did not stop fire
Duplication	1435 Aug. 14	35	High	Did not stop fire
DAP (28%)				
First burn	1205 Aug. 14	35	High	Did not stop fire
Duplication	1415 Aug. 14	35	High	Did not stop fire
Algin (.48%)				
DAP (15%)				
First burn	1225 Aug. 14	35	High	Fire burned in
Duplication	1400 Aug. 14	35	High	Fire burned in
Algin (.48%)				
DAP (20%)				
First burn	1240 Aug. 14	35	High	Fire burned in
Duplication	1340 Aug. 14	35	High	Fire burned in
Algin (.48%)				
DAP (28%)				
First burn	1305 Aug. 14	35	High	Stopped fire
Duplication	1325 Aug. 14	35	High	Stopped fire
DAP (15%)				
Second burn	1115 Sept. 27	79	Medium	Did not stop fire
Duplication	1430 Sept. 27	79	Low	Did not stop fire
DAP (20%)				
Second burn	1135 Sept. 27	79	Medium	Did not stop fire
Duplication	1415 Sept. 27	79	Low	Slowed
DAP (28%)				
Second burn	1150 Sept. 27	79	Medium	Did not stop fire
Duplication	1355 Sept. 27	79	Low	Did not stop fire
Algin (.48%)				
DAP (15%)				
Second burn	1205 Sept. 27	79	Medium	Slowed fire
Duplication	1340 Sept. 27	79	Low	Fire burned in
Algin (.48%)				
DAP (20%)				
Second burn	1220 Sept. 27	79	Medium	Fire burned in
Duplication	1315 Sept. 27	79	Low	Stopped fire
Algin (.48%)				
DAP (28%)				
Second burn	1235 Sept. 27	79	Low	Stopped fire
Duplication	1250 Sept. 27	79	Low	Stopped fire

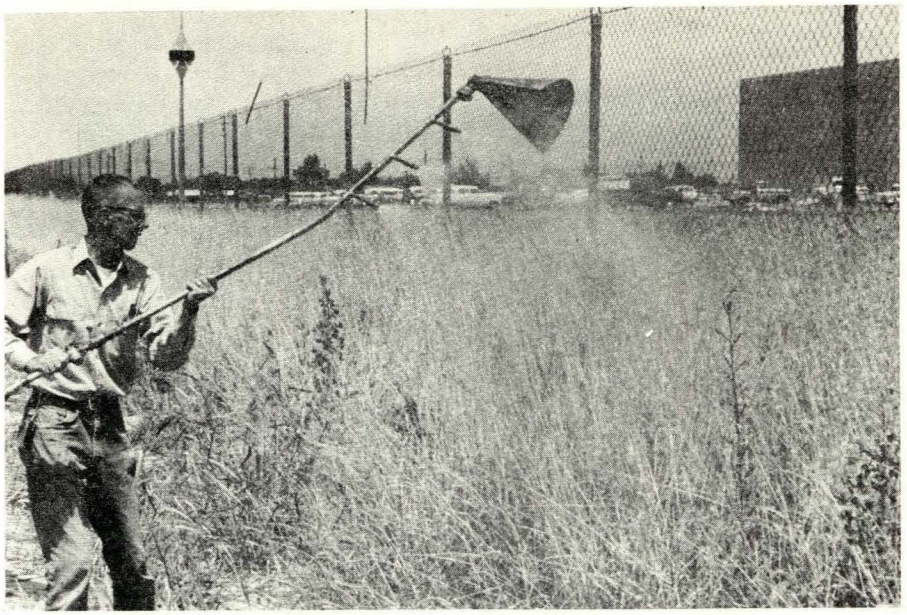

Figure 1.--Applying fire retardant chemicals to the Pleasant Hill test plots.

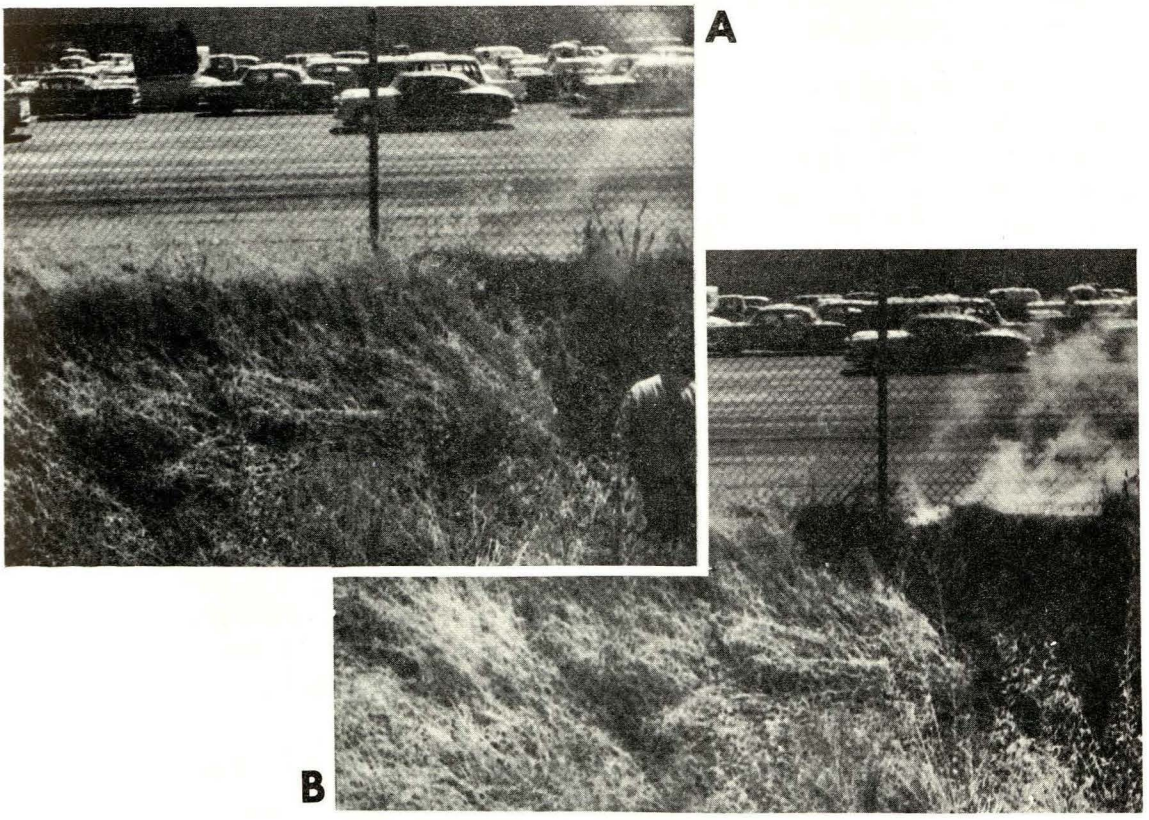

Figure 2.--Test plot at Pleasant Hill: A, Untreated grass has been ignited and fire is spreading into the treated area; B, the fire stopped after burning a short distance into the treated area.

Figure 3.--Crew using the Arcadia Equipment Development Center mixer on the Angeles National Forest.

To determine how long the DAP would remain effective, we burned the plots at various intervals. The first 12 plots were burned on August 14—35 days after application. A third burn was scheduled for late in the fire season, but an unusual October storm totaling 14 inches flooded the test site, and the plan was dropped.

Although ignition by several methods was tried, most of the plots were ignited by drip torch. The plots were ignited in as uniform a manner as possible in the untreated portion of the plot and the fire allowed to spread to the treated part. Rate-of-spread observations were made during the course of the fire, and photographs were taken of each burn (fig. 2). Weather observations and the moisture content of the fuels were also recorded at the time of each burn.

Angeles Forest Tests.--Thirty-six 20- by 25-foot plots were established on the Angeles National Forest. One half of each plot was sprayed with 5.0 gallons of retardant (2 gallons per 100 square feet, as at Pleasant Hill). The retardants used in this test were two concentrations each of: algin-DAP, sodium silicate-DAP, and sodium silicate-algin-DAP (table 2).

The chemicals were mixed and pumped by a truck mounted mixer originally developed by the Arcadia Equipment Development Center for airport use (fig. 3). The 300-gallon mixer did an excellent job of mixing and pumping the various retardants. However, the mixing crew soon found that

the liquid sodium silicate solution could be added only to plain water. The DAP had to be added later. If a small quantity of DAP was present in the tank, the silicate would immediately go out of solution and form glass-like crystals in the bottom of the tank. Considerable care was required in cleaning and flushing out the mixer, pump, and hose before new batches could be mixed.

Table 2.--Effects of retardants with various concentrations and drying times, Angeles National Forest site

Retardant & concentration	Time of burn (Oct. 25)	Drying time (days)	Burning intensity	Effect of retardant	
				Light fuels	Heavy fuels
Algin (.48%) DAP (20%)					
First burn	1030	6	High	Stopped fire	Stopped fire
Duplication	1045	6	High	Stopped fire	Stopped fire
Algin (.48%) DAP (30%)					
First burn	1100	6	High	Stopped fire	Stopped fire
Duplication	1115	6	High	Stopped fire	Stopped fire
Algin (.48%) DAP (20%) Silicate (2%)					
First burn	1130	6	High	Fire burned in	Slowed
Duplication	1200	6	High	Slowed	Slowed
Algin (.48%) DAP (30%) Silicate (2%)					
First burn	1230	6	High	Stopped fire	Slowed
Duplication	1250	6	High	Stopped fire	Fire burned in
DAP (20%) Silicate (2%)					
First burn	1315	6	Low	Stopped fire	Stopped fire
Duplication	1330	6	Low	Stopped fire	Stopped fire
DAP (30%) Silicate (2%)					
First burn	1350	6	Low	Stopped fire	Stopped fire
Duplication	1410	6	Low	Stopped fire	Stopped fire

The plots were burned once, six days after application, on October 25. Unfavorable conditions prevented further testing. Ignition was in the same manner as at Pleasant Hill.

In both tests, retardant effectiveness was listed by the observer into one of four classes:

1. The fire was completely stopped at the edge of the retardant-treated area.
2. The fire burned into the retardant-treated area but was eventually stopped.
3. The fire was slowed by the retardant but burned through the entire treated area.
4. Fire spread was not appreciably affected by the retardant.

Fire intensity was largely a result of weather conditions before and during the test. The intensity in the untreated portion of the plot was rated by the evaluator in one of three relative categories:

1. High intensity.
2. Medium intensity.
3. Low intensity.

Results, Pleasant Hill Test

Weather before the first burn, 35 days after application, was generally milder than normal for the fire season. During the day of the first burn the temperature ranged from 84° to 92°F. and relative humidity from 30 percent to 37 percent. Fuel moisture of grass averaged 9.5 percent. Wind was from the northeast at 3 m.p.h.

During this test, unthickened DAP solutions of all three concentrations failed to stop the test fires (table 1). We did not detect any difference in the effectiveness of the three different concentrations.

Viscous-DAP eventually stopped the fires in all cases. However, this time the amount of fire penetration into the treated area was dependent upon the concentrations of the DAP solution.

The second burn, 79 days after application, was conducted after 0.18 inches of rain. There were indications that the effectiveness of the retardant depended not only on concentration of DAP but also on the use of viscosity agents. At the time of the test, weather conditions were marginal for burning, with relative humidities as high as 59 percent. As a result, the plots burned extremely erratically.

Results, Angeles National Forest Test

The first and only burn on the Angeles National Forest plots was conducted on October 25, 1962, six days after application (table 2). Like the rest of the State, this area had experienced a mild fire season. At the time of the test, the temperature was 82° and the relative humidity

24 percent. Fine fuel moisture content was 2.3 percent, and the wind 3-6 miles per hour from the southeast. The viscous-DAP solutions in most cases stopped the fire in grass regardless of concentrations, but the solutions only temporarily slowed the fire in heavier fuels. The rate of spread in larger fuels was reduced, but eventually the fires burned into or through the treated areas.

The addition of sodium silicate to either thickened or unthickened solutions of DAP had no apparent affect on how the plots burned.

Fuel size and volume seemed to have more influence on rate of spread in the test plots than either the quantity or composition of the retardant.

Discussion

Information obtained from both test sites permits us to draw the following conclusions:

1. Viscous-DAP can stop fires in grass up to 79 days after application.
2. Plain water solutions of DAP in concentrations of 15-28 percent may prevent grass fires from igniting soon after application, but these solutions lose effectiveness in summer weather within 35 days.
3. The application rate of 2 gallons of viscous-DAP per 100 square feet appears to be adequate in light fuels such as grass but is ineffective in larger fuels such as brush.
4. Although viscous-DAP solutions offer promise, particularly in light fuels, their effectiveness is reduced or eliminated by rainfall.
5. The cost of chemicals for fireproofing roadsides will probably vary from 14 to 20 cents per gallon depending on additives and concentration of DAP.
6. Application methods are important. Field crews using hand application methods will need to be well trained.

Thus, much remains to be learned. We need to know the specific amounts of viscous-DAP required for various fuel sizes and densities. We need to find either a "sticker" or "spreader" compatible with DAP which will resist summer rains, or a less soluble form of phosphate. Nevertheless the approach looks promising, and additional studies are planned that may bring us the answers.

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